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ABSTRACT

Adjunct questions were inserted after each of 12 computer-animated graphics sequences shown to 160 eighth-grade science students. These sequences presented two relationships in a purely spatial fashion. Four randomly assigned treatment groups received questions targeting one of the two relationships (temperature or molecular motion) over all or part of the 12 sequences. A control group received placebo postquestions. Significant interactions among treatment groups and posttest items ("low-level" comprehension) were found for each targeted relationship. Furthermore, interactions were stronger for students receiving postquestions covering all sequences. These findings extend previous research to include spatial as well as textual media. (Author)

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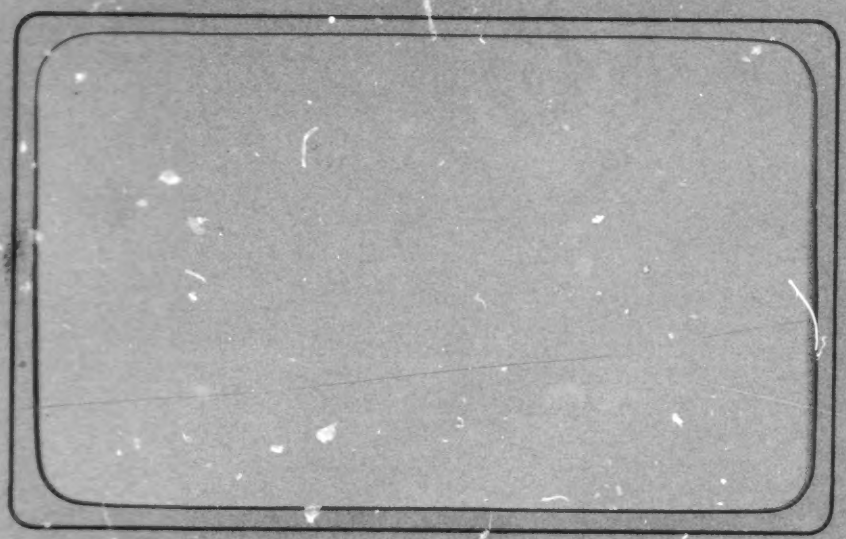

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Carry-Over Effects of Focusing Postquestions Adjunct to Computer Animated Graphics

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Abstract

Adjunct questions were inserted after each of 12 computer-animated graphics sequences shown to 160 eighth-grade science students. These sequences presented two relationships in a purely spatial fashion. Four randomly assigned treatment groups received questions targeting one of the two relationships (temperature or molecular motion) over all or part of the 12 sequences. A control group received placebo postquestions.

Significant interactions among treatment groups and posttest items ("low-level" comprehension) were found for each targeted relationship. Furthermore, interactions were stronger for students receiving postquestions covering all sequences. These findings extend previous research to include spatial as well as textual media.

Introduction

The advent of the microcomputer has put the use of computer-animated graphics, as a technique of presenting learning materials, within the reach of most North American schools. Thus, the choice of effective teaching procedures or instructional designs to be used with animated spatial

instructional materials is one of ever increasing importance. Research into the learning effects of postquestions when used adjunct to textual materials has shown them to be a quite effective method of enhancing learning (Anderson & Biddle, 1975; Andre, 1979; Rickards, 1979; Reynolds & Anderson, 1982). It seemed that this paradigm might suggest techniques that would prove effective in enhancing learning from simulations in the form of computer-animated graphics.

One model often used to explain the effects of adjunct questions is the "selective attention model." This model assumes that if students are not able to handle the total learning task then they will focus on those portions of the task which they perceive to be most important (Andre, 1979). Undirected, this focusing of attention is apt to be haphazard and unproductive (Anderson, 1970). Moreover, the model predicts that if postquestions repeatedly query a restricted or targeted category of information, then the students will try to anticipate the nature of the upcoming learning tasks (Andre, 1979). Such anticipation should result in students focusing on or attending to the targeted category of information at the expense of the other categories of information. Selective attention behavior should then result in enhanced performance on posttest items querying the targeted information category. Furthermore, the use of adjunct questions can reduce the need to continually monitor students' attentional processes, a primary instructional variable, according to Anderson and Biddle (1975) and Andre (1979).

One aspect of adjunct question research that is the subject of much debate, is the relationship between the taxonomic level of the adjunct questions and the type of processing or encoding in which they would result. Early research (Rothkopf, 1965, 1966; Frase, 1968; Anderson, 1970; McGaw & Grotelueschen, 1972) explored the effects of verbatim versus paraphrased questions. The "depth of processing" hypothesis (Craik & Lockhart, 1972) predicted that asking higher-level questions would automatically result in a greater likelihood of semantic encoding. Later studies indicated that the situation was not quite so cut and dried as it was earlier predicted. Other factors, such as the difficulty level of the questions, the frequency of insertion and the mode of response, all influenced the effectiveness of adjunct questions in causing focusing and the level of encoding which resulted from their use (Watts & Anderson, 1971; Anderson & Biddle, 1975; Andre & Womack, 1978; Andre, Meuller, Womack, Smid & Tuttle, 1980). The present study tried to address the question of how students' depth of processing was affected by the question level when the learning materials were in the form of spatial media rather than textual media.

Aspects of students' ability to focus their attention and retain that focus in the face of distractions was also explored in the present study. In the past, many unique and intriguing experiments have been done to explore the ability of students to focus on restricted categories of information. Reynolds, Standiford and Anderson (1979) used textual displays on video display terminals (VDTs) controlled by a computer to measure

the time each student spent reading each passage. They discovered that the students spent more time reading those passages which contained information targeted by previous postquestions than those passages which did not. The increased reading time indicated that the students were devoting increased attention to the targeted information categories. In a similar experiment, Reynolds and Anderson (1982) found that not only did students take longer to read passages containing targeted information categories, but they were slower to respond to a "secondary task probe" while reading these passages. The increased response time to the probe indicated that the students were probably more engrossed in the primary task.

There seems little doubt that students do, in fact, focus their attention on restricted categories of information as the result of the use of adjunct questions when used with textual materials. However, the research question remains as to the duration of this focus when it is not being reinforced by the continual use of adjunct postquestions. The present study attempted to explore this line of questioning by presenting two of the treatment groups with target-category postquestions after the early computer-animated sequences but not after the later sequences. In this manner, it was hoped that we would discover whether or not the focusing, induced by the early use of postquestions, was still present over the later sequences.

Past research has been predominantly concerned with the use of adjunct questions with textual materials. Although research has been done on the use of adjunct questions with

diagrams (Winn & Holliday, 1982), these researchers were primarily concerned with diagrams and their relationship to text. The direction of the present study was to use computer-animated graphics to replace text as the medium of information presentation. Computer-controlled VDTs presented purely spatial materials. Only the postquestions and the posttest used text.

Method

Materials

A computer program was written which presented, using computer-animated graphics, an analogy of the effect of heating on the temperature and the molecular motions of a material. This analogy traced the relationships from the heating of the material in its solid phase, through melting and heating of the material in its liquid phase. In each of the 12 computer-animated sequences, heat was graphically added to the material and the effect of the heat on the temperature and the molecular motion as predicted by the "kinetic molecular theory of matter" was shown (Figure 1). From the sequences several of the premises of the kinetic molecular model of matter could be inferred. The information presented in these sequences was a prescribed topic of the students' science curriculum.

The adjunct questions which were presented following each sequence queried some aspect of the information from that sequence. Three kinds of postquestions were designed. Type "CT" postquestions targeted the relationship between the addition of heat to the material and the change in temperature

that resulted. Type "SM" postquestions targeted the effect of heating on the speed of the molecules in the material. The third type of postquestion was a placebo postquestion. Although each placebo postquestion queried information found in the preceding sequence, as a group they neither targeted any one concept nor queried any information relevant to the posttest questions. All postquestions were pictorially explicit in that the answer for each question was explicitly presented in the preceding sequence. As such, the postquestions used in this study were considered to require a "low-level" of comprehension by the students.

A posttest which involved low- and high-levels of comprehension was designed. Low-level comprehension posttest items were defined as those which queried pictorially explicit information. To answer pictorially explicit questions, a student would have to recall information as presented in the sequences. High-level comprehension items, on the other hand, queried pictorially implicit information. These items asked students to solve verbal and quantitative problems from the concepts presented in the sequences.

Design and Procedure

The eighth-grade students (n = 160) were randomly assigned to one of four treatment groups or a control group. Treatment group "CT12" received a postquestion after each of the 12 computer-animated sequences which targeted the effect of heating on the change in temperature of the material. Similarly, treatment group "SM12" received postquestions on the

effect of heating on the speed of the molecules after each of the 12 sequences. Group "CT8" received postquestions targeting the effect of heating on the change in temperature after each of the first eight sequences. After each of the final four sequences, this treatment group (CT8) received a placebo postquestion in place of the target-category postquestion. The pattern of postquestions for treatment group "SM8" was the same as that for CT8 except that the target-category postquestions presented were those querying the effect of heating on the speed of the molecules. The control group received a placebo postquestion after each of the 12 computer-animated sequences.

The students viewed each sequence then turned to a question booklet and responded to, in a paper and pencil fashion, one of the three types of postquestions. Following the treatment, the students turned to a test item booklet and answered low- and high-level comprehension posttest questions.

Data and Data Analysis

The means and standard deviations for each of the data categories were calculated (Table 1). The posttest scores were evaluated using four separate two-way analysis of variance tests to determine the presence of significant interactions. The performance of the treatment groups was also compared with that of the control group for each of the targeted information categories using Newman-Keuls multiple range tests. In all cases, significance was sought at the 0.05 alpha level.

The Newman-Keuls multiple range tests indicated that the treatment groups' performance on the pictorially explicit

posttest items querying the information category targeted for that group was significantly higher than the control groups' performance on those same posttest items. In other words, the group receiving postquestions targeting change in temperature relationships outperformed the control group on the pictorially explicit posttest items querying change in temperature but not on the posttest items querying molecular speed relationships. This was true for both targeted information categories for both manners of presentation (i.e. using 12 or eight target-category postquestions). No treatment group significantly outperformed the control group in answering the pictorially implicit posttest questions.

Significant interactions, $F(1,126) = 27.7$, $p < 0.05$ and $F(1,123) = 4.1$, $p < 0.05$, were found for each of the targeted categories of information among treatment groups (CT12/SM12 and CT8/SM8, respectively) and the pictorially explicit posttest items (low-level comprehension). These interactions are shown in Figures 2 and 3. Furthermore, the reactions were stronger for groups receiving target-category postquestions after all sequences than they were for the groups receiving eight target-category followed by four placebo postquestions. No significant interactions were found for any of the treatments and the pictorially implicit posttest questions (high-level comprehension). As anticipated, the control group failed to show any evidence of selective attention behavior.

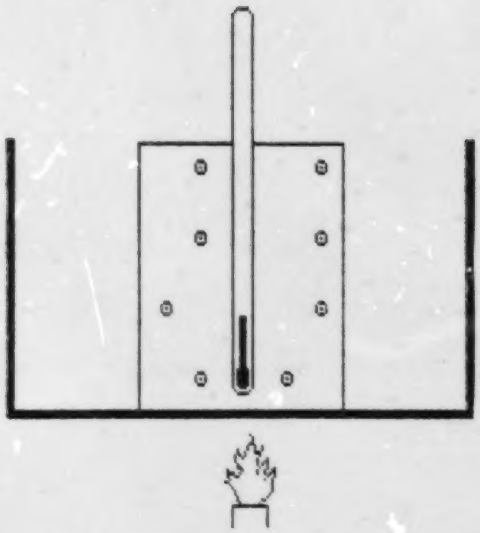
Discussion

The present study had two primary goals. The first goal was to determine whether or not the learning effects of postquestions when used with textual materials could be extrapolated for use with purely spatial materials. The study contributed to the selective attention model in that it indicated that students' attentional processes can be directed by adjunct postquestions when used with purely spatial learning materials. Specifically, the results support a claim that postquestions are effective in producing direct learning effects when used with computer-animated displays employing visually mobile elements. This phenomenon will likely become increasingly important in classrooms of the future.

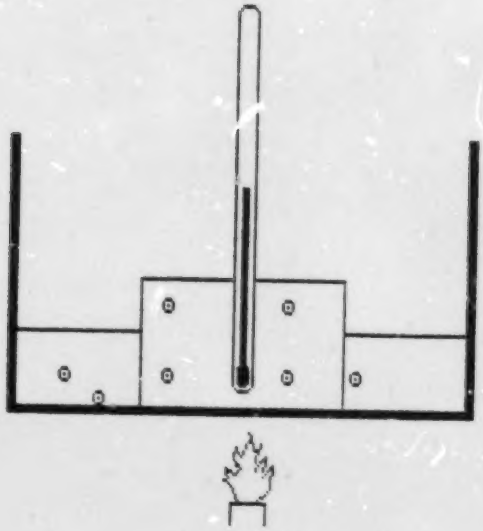
The second primary goal of the present study was to determine if, once an attentional set had been induced, the focusing behavior of the students would persist after the presentation of target-category postquestions had been replaced by placebo postquestions. The interaction between the treatment groups CT8 and SM8 on the pictorially explicit posttest items indicated that these groups had retained the focusing effect induced by the target-category postquestions presented earlier. Thus, the study further contributed to the selective attention model in that it suggested that students' selective attention behavior persisted in some fashion beyond the immediate scope of the adjunct question presentation.

The present study contributed to other aspects of the selective attention model as well. Third, the study used materials in a naturalistic setting and in a naturalistic

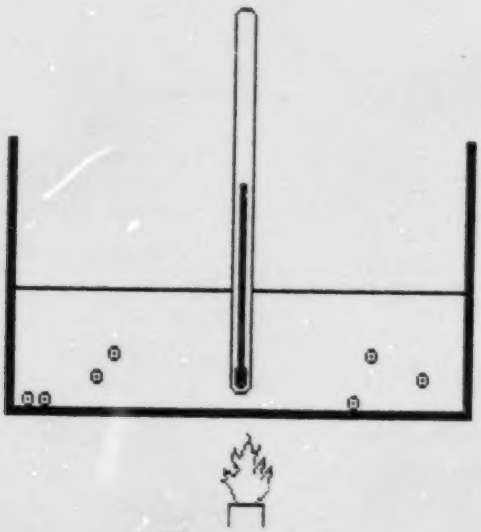
manner. The method of presentation very closely paralleled the manner in which the materials would be used in a normal classroom setting and used a topic from the normal curriculum. Fourth, the content of the "lesson" and its relationship to the questions used, both as postquestions and on the posttest, were carefully attended to in order to maintain a reasonable face validity. Classroom teachers of students at the same level as those involved in the study were consulted in order to ensure that the materials and the questions were appropriate to the curriculum. Fifth, the study conformed to the guidelines of postquestion design described by Anderson (1972), Andre (1979) and Wixson (1983) in terms of reducing threats to internal validity.



Example of a VDT Display During a "Heating the Solid" Sequence



Example of a VDT Display During a "Melting" Sequence



Example of a VDT Display During a "Heating the Liquid" Sequence

Figure 1

Example of the VDT Displays

Table 1

Proportional Mean Scores and Standard Deviations For Posttest Questions

Group	Posttest Items			
	Pictorially Explicit		Pictorially Implicit	
	Change in Temperature	Speed of Molecules	Change in Temperature	Speed of Molecules
CT12	0.58 (0.17)*	0.47 (0.14)	0.20 (0.21)	0.11 (0.18)
SM12	0.40 (0.16)	0.59 (0.19)	0.15 (0.13)	0.16 (0.19)
CT8	0.59 (0.21)	0.49 (0.16)	0.21 (0.19)	0.10 (0.17)
SM8	0.42 (0.14)	0.44 (0.20)	0.12 (0.17)	0.09 (0.19)
Control	0.41 (0.13)	0.40 (0.21)	0.17 (0.18)	0.08 (0.13)

* Numbers in Brackets are the standard deviations.

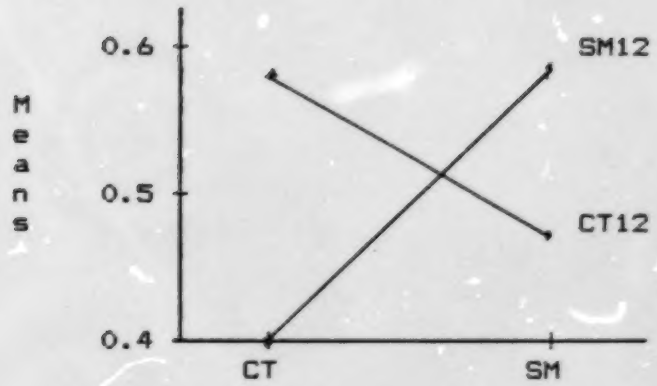


Figure 2

Interactions of Groups CT12 and SM12 on Pictorially Explicit Posttest Items

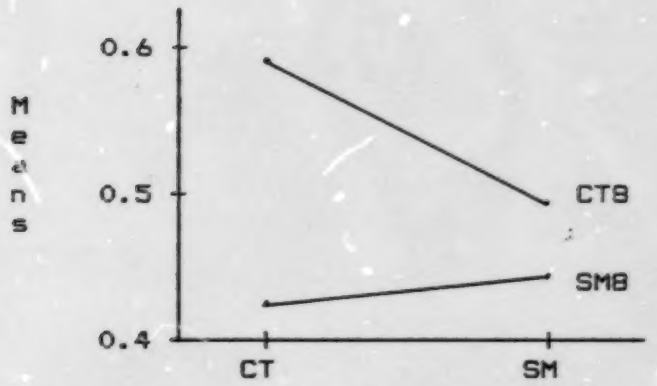


Figure 3

Interactions of Groups CT8 and SM8 on Pictorially Explicit Posttest Items

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